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SHIP RADAR COVERAGE FOR THE TWO-AND-ONE-HALF-STAGES-TO-ORBIT TECHNIQUE

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Guidance and Performance Branch

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
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PROJECT APOLLO

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SUMMARY

This report presents the results of a study to select the number and positions of the tracking ships needed to satisfy the ground support requirements for the two-and-one-half-stages-to-orbit technique.

This report shows the acquisition of signal (AOS), loss of signal (LOS), range, azimuth and elevation data for each radar station considered in the study.

INTRODUCTION

The two-and-one-half-stages-to-orbit technique is a scheme by which additional payload can be gained by using the CSM as a third stage during the launch trajectory. The intent of this report is to define the number of tracking ships required and their locations from which the launch trajectory would have adequate tracking coverage. The Manned Space Flight Network (MSFN) ground stations considered for this report were: Stations in the vicinity of Cape Kennedy, Florida; Wallops Island, Virginia; and Bermuda. The coverage from the stations near Cape Kennedy overlaps the coverage from the station at Bermuda to provide adequate coverage of the launch trajectory through SPS ignition. Wallops Island covers a portion of the trajectory that is covered adequately by Bermuda and is not presented.

The data for this report was generated with the aid of the ARM04 computer program, which uses the iterative guidance mode (IGM) equations to guide the S-IVB to its specified target.

DISCUSSION

The trajectory constraint of an orbital inclination of 50° dictates that the only MSFN station available for launch monitoring is Bermuda.

The primary question to be answered by this study is how many ships to use and where to position them for coverage of the two-and-one-half-stages-to-orbit technique.

The following are the constraints that were imposed upon the two-and-one-half-stages-to-orbit technique:

1. Insert into a 81- by 120-n. mi. orbit having an inclination of 50° and having no yaw steering in the S-IVB and CSM stages.

2. The ships radar AOS and LOS occurs at an elevation of 5° from the local horizontal.

3. The ships give cover insertion plus 3 minutes of post-insertion coast.

As stated above, the ARMO4 program was used to generate the data for this study. Analysis of this data offers two approaches to solving the problem. They are as follows:

1. The first approach is to use the ground station Bermuda to cover the beginning of the SPS burn. A tracking ship positioned at 47.3° N latitude and 42° W longitude covered insertion and 3 minutes after insertion. The position of the ship and resulting coverage are shown in figure 1.

2. The second approach uses Bermuda to cover SPS ignition and two tracking ships for the remainder of the burn. The first tracking ship is located at 46.2° N latitude and 54° W longitude and the other at 49.2° N latitude and 34.8° longitude. This gives complete coverage of the SPS burn and the 3 minutes after insertion. The positions of the ships and the resulting coverage are shown in figure 2.

Table I lists the ground and ship radar stations and their position coordinates. Figure 3 presents the radar range, elevation and azimuth as a function of elapsed time from lift-off for Bermuda and each of the three tracking ships.

CONCLUSIONS

It is assumed that there is a requirement for total coverage of the launch trajectories. The results of this study show that two ships and Bermuda would be required to track the vehicle through the entire launch trajectory and 3 minutes of post-insertion coast. For optimum coverage the ships should be located at 46.2° N, 54°W, and 49.2° N, 34.8°W.

TABLE I.- RADAR STATION AND SHIP POSITION COORDINATES

Station	Latitude, deg	Longitude, deg	Range, n. mi.
Bermuda	32.3475278 N	64.653556 W	32 000
Ships:			
One	47.5 N	42 W	23 400
Two	46.2 N	54 W	23 400
Three	49.2 N	34.8 W	23 400

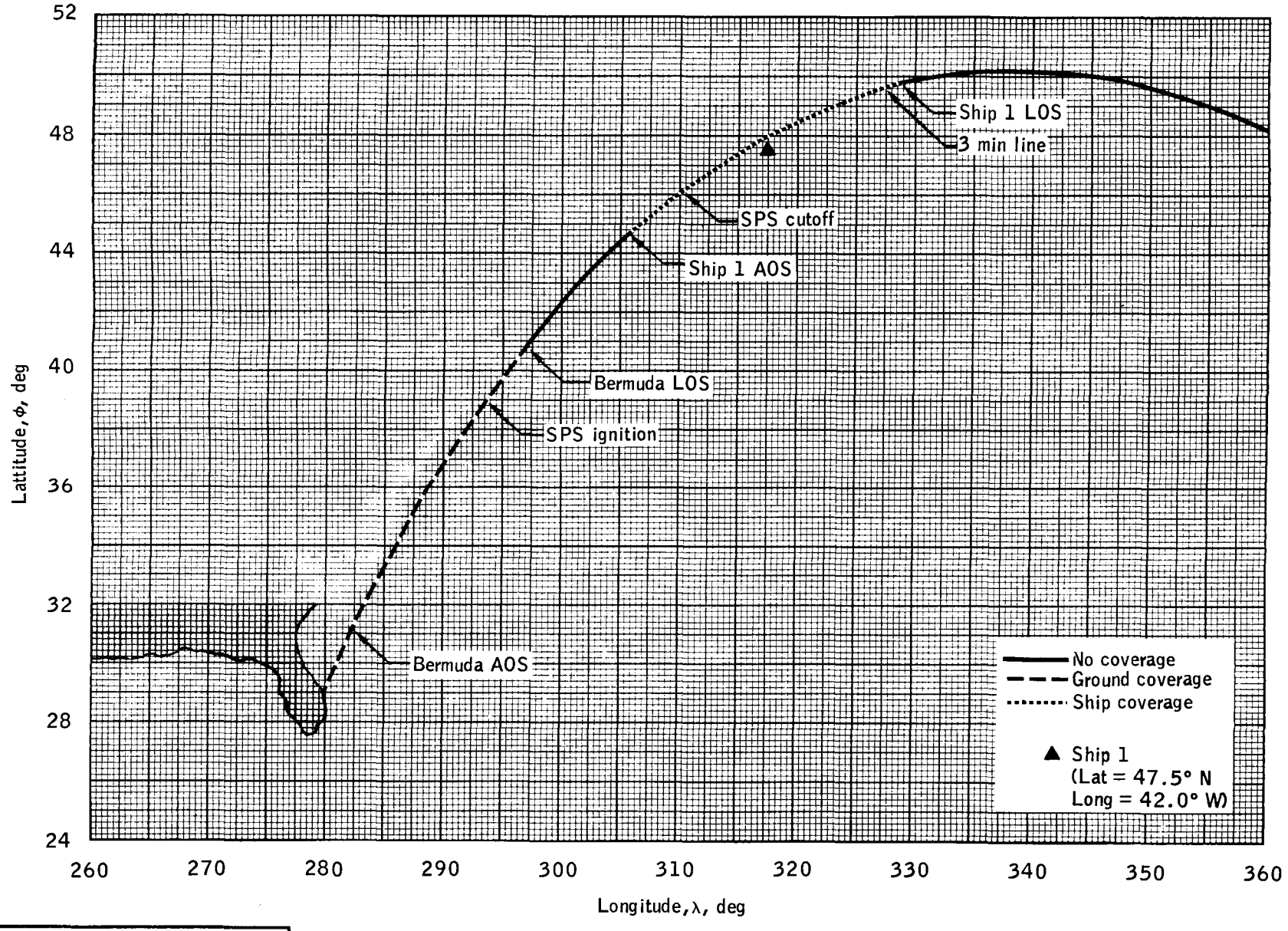

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Figure 1.- Radar coverage by ship 1 of the two-and-one-half stages-to-orbit technique.

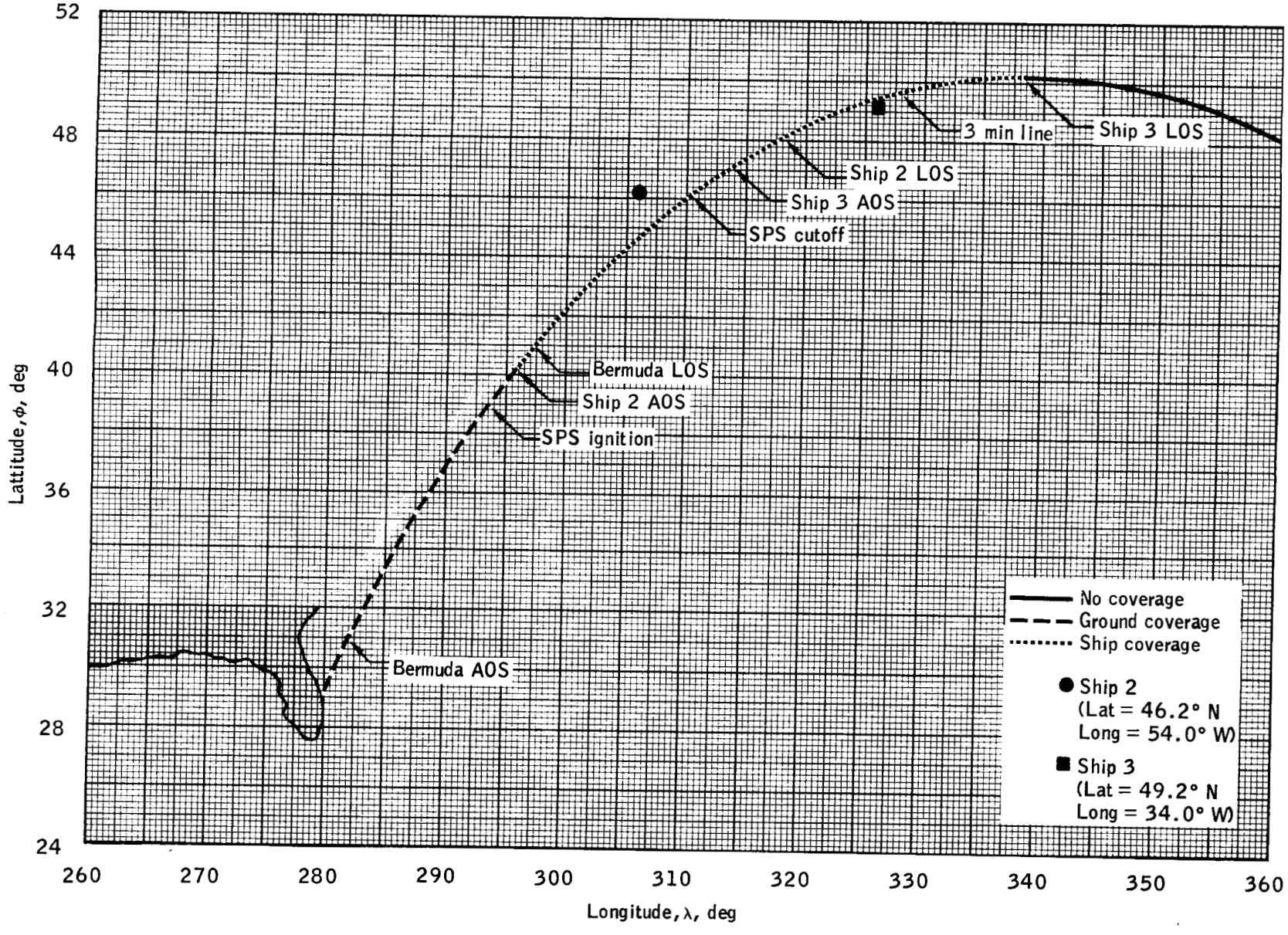

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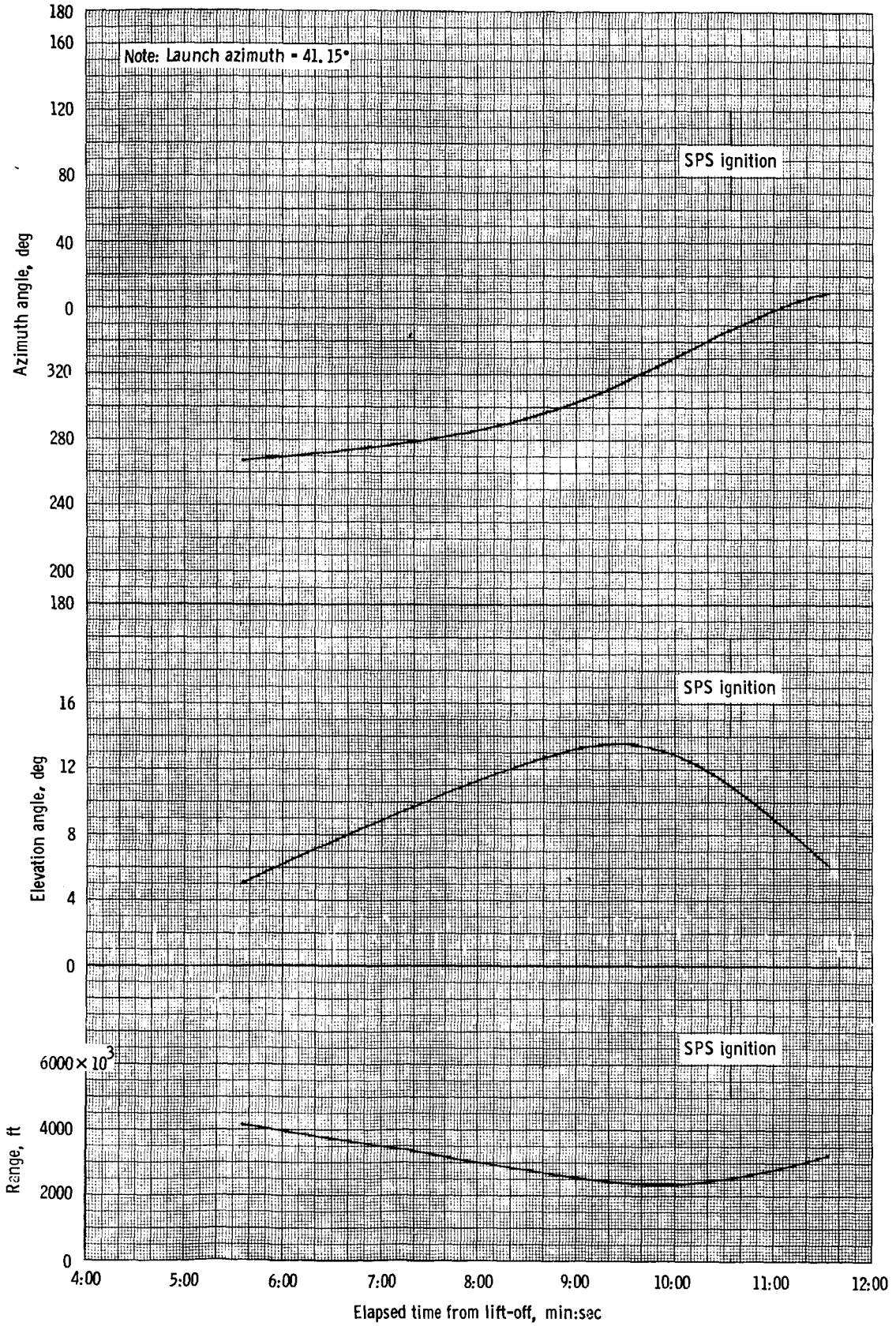
Figure 2.- Radar coverage by ship 2 and 3 of the two-and-one-half stages-to-orbit technique.



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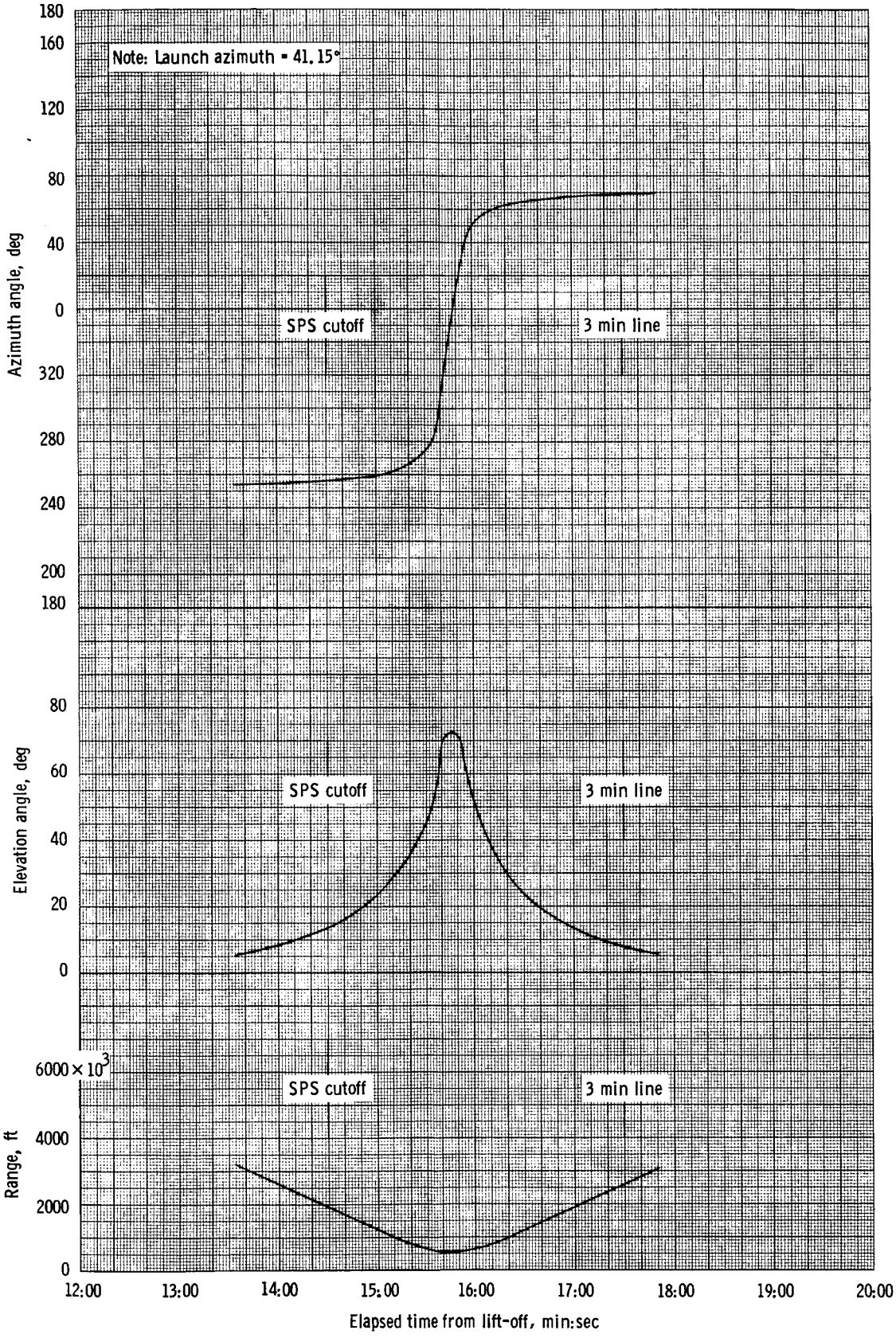
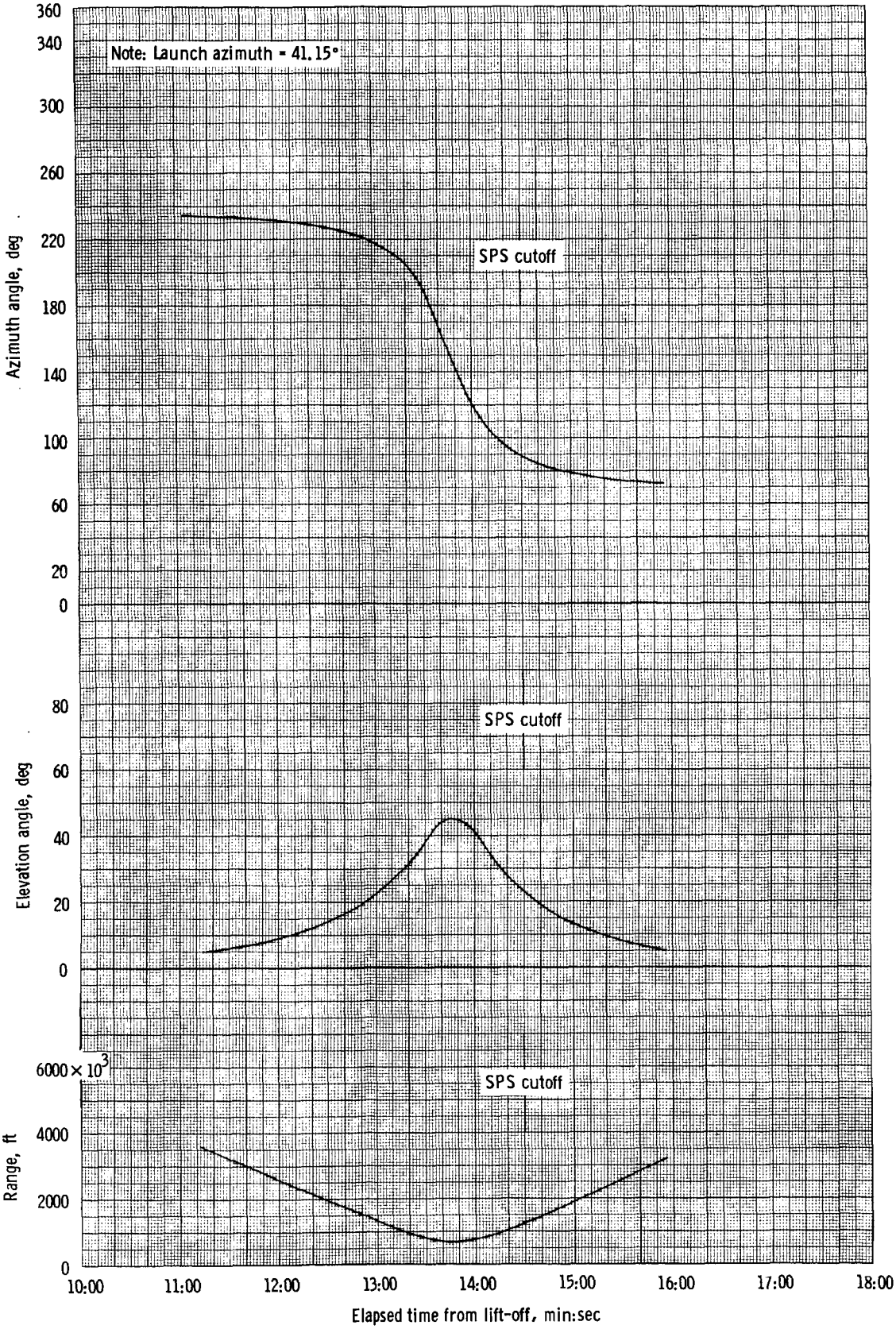
(a) Bermuda.

Figure 3.- Time history of radar pointing data for the two-and-one-half stages-to-orbit technique.



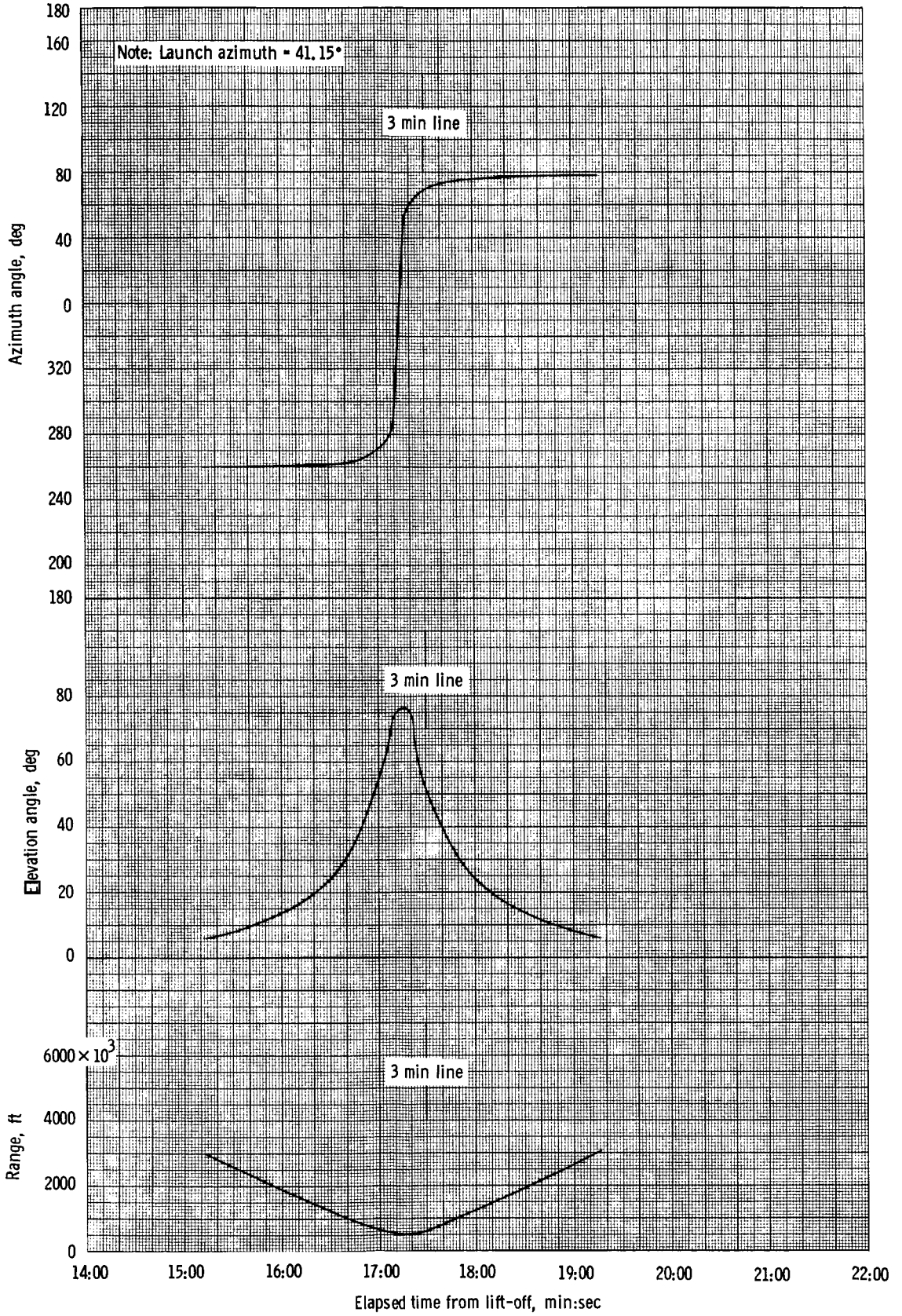
(b) Ship 1.

Figure 3. - Continued.



(c) Ship 2.

Figure 3. - Continued.



(d) Ship 3.

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Figure 3. - Concluded.